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36. A process for the preparation of nanostructured materials in high phase purities comprising:
- a) mixing a metal containing solution with a precipitating agent to form a mixed solution that precipitates a product; and
  - b) passing the mixed solution at elevated pressure into a cavitation chamber to create cavitation thereby forming a cavitated precipitated product, said cavitation chamber includes:
    - i) means for creating a cavitation zone, and
    - ii) means for controlling said cavitation zone by providing adjustable back pressure within said cavitation zone.
37. The process of claim 36, wherein at least some precipitation of the mixed solution occurs in step (b).
38. The process of claim 36, wherein both high shear and at least some in situ calcination of the mixed solution occur in the cavitation chamber.
39. The process of claim 36, wherein said means for creating said cavitation zone includes a first element internally situated within a flow-through channel having a flow area wherein said first element produces a local constriction of the flow area, said cavitation zone is formed immediately after said first element.
40. The process of claim 36, wherein said cavitation chamber further comprises means for creating a second cavitation zone to produce a multi-stage process.
41. The process of claim 40, wherein said means for creating said second cavitation zone includes a second element internally situated within said flow-through channel having a second flow area downstream of said first element wherein said second element produces a second local constriction of the second flow area, said second cavitation zone is formed immediately after said second element.

42. The process of claim 41, wherein said means for controlling said cavitation zone is varying the distance between the first and second element to provide adjustable back pressure within said cavitation zone.
43. The process of claim 41, wherein said means for controlling said cavitation zone is the second local constriction produced downstream of said first element thereby providing adjustable back pressure within said cavitation zone.
44. The process of claim 41, wherein said cavitation chamber further comprises means for controlling said second cavitation zone to produce a multi-stage process.
45. The process of claim 44, wherein said means for controlling said second cavitation zone includes a third element internally situated within said flow-through channel downstream of said second element to produce a third local constriction downstream of said second element thereby providing adjustable back pressure within said cavitation zone.
46. The process of claim 39, wherein said means for controlling said cavitation zone includes a second element internally situated within said flow-through channel downstream of said first element to produce a second local constriction thereby providing adjustable back pressure within said cavitation zone.
47. The process of claim 46, wherein said means for controlling said cavitation zone creates an elevated pressure zone between said cavitation zone and said second local constriction.
48. The process of claim 46, wherein said second element is a control valve.

49. A process for the preparation of nanostructured materials in high phase purities comprising:
- a) mixing a metal containing solution with a precipitating agent to form a mixed solution that precipitates a product; and
  - b) passing the mixed solution at elevated pressure and at a velocity into a cavitation chamber to create cavitation thereby forming a cavitated precipitated product, said cavitation chamber includes:
    - i) means for creating a cavitation zone, and
    - ii) means for controlling said cavitation zone by providing back pressure within said cavitation zone.
50. The process of claim 49, wherein at least some precipitation of the mixed solution occurs in step (b).
51. The process of claim 49, wherein both high shear and at least some in situ calcination of the mixed solution occur in the cavitation chamber.
52. The process of claim 49, wherein said means for creating said cavitation zone includes a first element internally situated within a flow-through channel having a flow area wherein said first element produces a local constriction of the flow area, said cavitation zone is formed immediately after said first element.
53. The process of claim 49, wherein the velocity of the mixed solution passing into the cavitation chamber is at a velocity sufficient to create cavitation bubbles to form downstream of the first element.
54. The process of claim 52, wherein said means for controlling includes a second element internally situated within said flow-through channel downstream of said first element to produce a second local constriction thereby providing back pressure within said cavitation zone to create an elevated pressure zone between said cavitation zone and said second local constriction.

- 55. The process of claim 54, wherein the cavitation bubbles are formed in said cavitation zone and the cavitation bubbles collapse in the elevated pressure zone.
- 56. The process of claim 55, wherein the second element provides adjustable back pressure within said cavitation zone to control said elevated pressure zone.
- 57. The process of claim 56, wherein the second element is a control valve.
- 58. The process of claim 49, further comprising a second cavitation chamber situated in series with said cavitation chamber.